

Circular Economy and Digitalization: Application to Industrial Systems

Université Paris-Saclay, CentraleSupélec, Laboratoire Génie Industriel

Opening position for a postdoctoral researcher in Circular Economy and Engineering

1. Context, motivations, and research challenges

Circular economy aims at minimizing the impacts of human activities on the environment, for example, by pooling material, water, and energy flows with a life cycle perspective and in an integrated metabolism approach. Circular economy is deployed thanks to strategies like industrial ecology, eco-design of products, services, and systems [1, 2] (www.lgi.centralesupelec.fr/en/node/182), and could be further enabled with the advancement and proper application of digital technologies and associated tools [3, 4]. For example, the promising potential of digitalization to automate and therefore foster and democratize the use of life cycle assessment (LCA) and material flow analysis (MFA) tools in industry [5]; or the use of digital technologies to help data analysis with the integration of artificial intelligence in circular economy and in circular product design [6].

Yet, new theoretical and experimental research is needed to understand, guide, and illustrate how digital tools can further operationalize and foster a sustainable circular economy at different levels [7, 8] (e.g., (re)manufacturing, collection, and recovery of products at an industrial level, recirculation of materials and energy flows at a regional level). Concretely, a recent comprehensive study [9] has highlighted a lack of an integrated and holistic analysis of the relationship between circular economy and digital technologies. At the same time, digitalization and sustainability are becoming such interconnected, timely, and strategic areas for companies and organizations to ignore for many competitive reasons, such as economics, environment, accountability, transparency, and innovation, to name a few [10, 11].

With this background, this project aims to investigate, exemplify, and quantify the role and potential of digitalization in the transition towards a more circular and sustainable economy. It aims to provide new and tangible insights to the following research question: *how could digital solutions contribute to keeping the momentum going for a smart circular economy (CE), and facilitating the implementation of CE strategies?*

2. Objectives and expected deliverables

Within the research chair Monitoring of Circular Economy (Pilotage de l'Economie Circulaire) held by Institut Louis Bachelier and CentraleSupélec, the candidate is expected to conduct upstream research on this topic in link with the specific needs, projects, operations, and capabilities of the partners (CPS, SIOM and VALE NC). Expected research outcomes may be (not limitative):

- Extensive literature review and industrial survey on digital tools for the circular economy ;
- Critical analysis on the potentials and current limitations of smart circular digital technologies ;
- Defining and experimenting use cases of digital solutions for augmented circular practices ;
- Identifying circular economy and digitalization-related value buckets for the partners ;
- Proposing *in fine* a roadmap with implementation plans and investment portfolio ;
- Performance assessment of such projects: cost-benefit analysis, circularity indicators, etc.

The candidate will also be asked to apply, as much as possible, his analyses and proposals to the use cases of the chair partners, i.e., the territory of “Communauté de Paris-Saclay” and the industrial installations and material flows of VALE NC. In addition, as CentraleSupélec and IRT SystemX are going to be partners and co-founders of the Alliance “Circular Economy and Digital Transformation” also involving the Communauté d’agglomération Paris-Saclay and dozens of industrialists, the candidate is expected to exploit the contexts of these Alliance members to consolidate his/her research analyses and proposals and make it more relevant.

Keywords: circular economy and territories resilience (material flows on a territorial/industrial/process level mobility, food, waste, solidarity economy, recycling centers) and digitalization (industry 4.0, integration of cyber-systems and physical resources, artificial intelligence, machine learning, digital twins for optimal resource management, real/virtual demonstrator/platform, modeling and simulation, visualization of flows/indicators, interface between indicators levels).

3. Candidate profile

The candidate has obtained a Doctoral degree in at least one of the following field: Circular Economy, Industrial Ecology, Industrial Engineering, Computer Science, or in a related field. A multidisciplinary profile would be appreciated.

He / She has a strong interest in sustainability, eco-design, computational tools, and new technologies.

Great communication and presentation skills – in French and English – are required to collaborate and exchange with industrial partners.

(Knowledge of life cycle assessment (LCA) and material flow analysis (MFA) tools is a plus, as well as the ability to code and/or develop practical and visual – web-based or excel-based – tools or mock-ups.)

4. Location, supervision and project team

The position will be based at CentraleSupélec, Paris-Saclay University within the Industrial Engineering Research Department (Laboratoire Génie Industriel, LGI, located at Gif-sur-Yvette, 20 km in the south-west of Paris). Note that hybrid in-person and virtual attendance/meetings might be commendable, according to the current sanitary situation.

The researcher will work under the supervision of Prof. Bernard Yannou, Prof. Isabelle Nicolai, and Assist. Prof. Yann Leroy. He / She will collaborate with Dr. Michael Saidani and Assist. Prof François Cluzel, with the partners of the Industrial Chair “Monitoring the Circular Economy”, and the Alliance “Circular Economy and Digital Transformation”.

5. Duration and starting date

Duration of the Project: 13 months, starting in fall 2021.

6. Application process

To apply, send your resume and optional cover letter directly to Prof. Bernard Yannou (bernard.yannou@centralesupelec.fr), Prof. Isabelle Nicolai (isabelle.nicolai@centralesupelec.fr), Assist. Prof. Yann Leroy (yann.leroy@centralesupelec.fr) and Dr. Michael Saidani (msaidani@illinois.edu).

For more information, please contact Prof. Bernard Yannou: bernard.yannou@centralesupelec.fr

7. Description of the hosting research lab

The Industrial Engineering (IE) Research Department ([Laboratoire Génie Industriel](#), LGI) is one of the 16 Research Units of [CentraleSupélec](#), a member of [Paris-Saclay University](#). It studies production, activity or socio-technical systems along their life cycles. These systems are engineered by humans and must be observed, diagnosed, exploited, regulated, maintained, and recycled.

The candidate will join the [Design Engineering Research Group](#), whose research aims at assisting complex system design and engineering activities, combining the product/service, process, and organizational dimensions. The main topics are about diagnosing, modeling, analyzing, simulating, and optimizing those complex systems. Design of sustainable systems is one of the main research axes and it aims at developing methods and tools to model, measure, and optimize sustainable performances of complex systems.

The launch of the chair “Monitoring the Circular Economy” with Communauté d’agglomération Paris-Saclay, SIOM, Vale NC, and the National Institute on Circular Economy (INEC) will actively support this activity research. New research works have also been initiated on the eco-design of digital services and the generation of sustainable architectures of complex industrial systems.

8. References and annexes

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- [2] Saidani, M., Yannou, B., Leroy, Y., Cluzel, F., & Kendall, A. (2019). A taxonomy of circular economy indicators. *Journal of Cleaner Production*, 207, 542-559.
- [3] Faludi, J., Hoffenson, S., Kwok, S. Y., Saidani, M., Hallstedt, S. I., Telenko, C., & Martinez, V. (2020). A research roadmap for sustainable design methods and tools. *Sustainability*, 12(19), 8174.
- [4] Alcayaga, A., Wiener, M., & Hansen, E. G. (2019). Towards a framework of smart-circular systems: An integrative literature review. *Journal of Cleaner Production*, 221, 622-634.
- [5] Grimal, L., di Loreto, I., & Troussier, N. (2019). Digital transformation as an opportunity for life cycle assessment. In 16ème Colloque National S-mart, April 2019.
- [6] Ghoreishi, S. (2019). Assessing the role of artificial intelligence in product design towards circularity. Master's Thesis. LUT University, School of Engineering Science, Global Management of Innovation and technology.
- [7] Bergmann, T., Guyot-Phung, C., & Atoniucci, D. (2019). How digital tools make circular economy operational industrial areas: The example of BE CIRCLE. *Journal of Business Chemistry*, 2019.
- [8] Rizvi, S. W. H., Agrawal, S., & Murtaza, Q. (2020). Circular economy under the impact of IT tools: a content-based review. *International Journal of Sustainable Engineering*, 1-11.
- [9] Cagno, E., Neri, A., Negri, M., Bassani, C. A., & Lampertico, T. (2021). The Role of Digital Technologies in Operationalizing the Circular Economy Transition: A Systematic Literature Review. *Applied Sciences*, 11(8), 3328.
- [10] Hallstedt, S. I., Isaksson, O., & Öhrwall Rönnbäck, A. (2020). The Need for New Product Development Capabilities from Digitalization, Sustainability, and Servitization Trends. *Sustainability*, 12(23), 10222.
- [11] Payer, B. (2021). Industry Report Shows Digitalization in Sustainability Trend Taking Hold. *Sphera Industry Report*. April 14, 2021.